

# P3E's Software Defined Transponder (SDX)

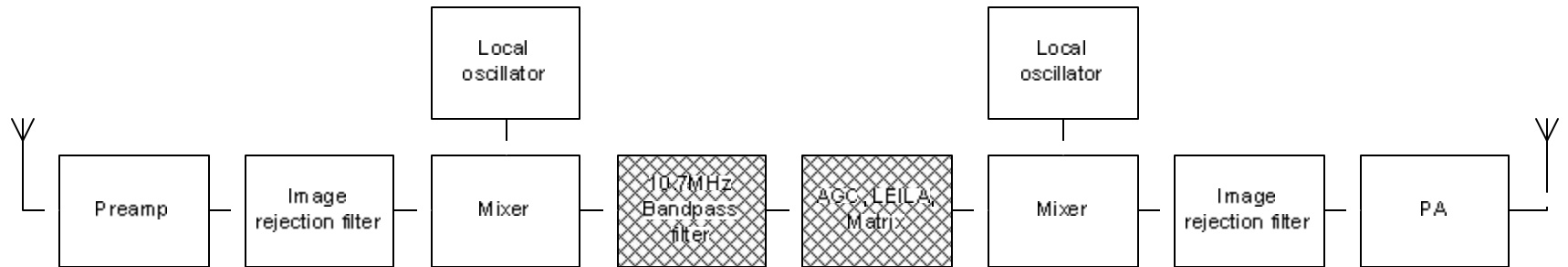
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AMSAT-NA Symposium

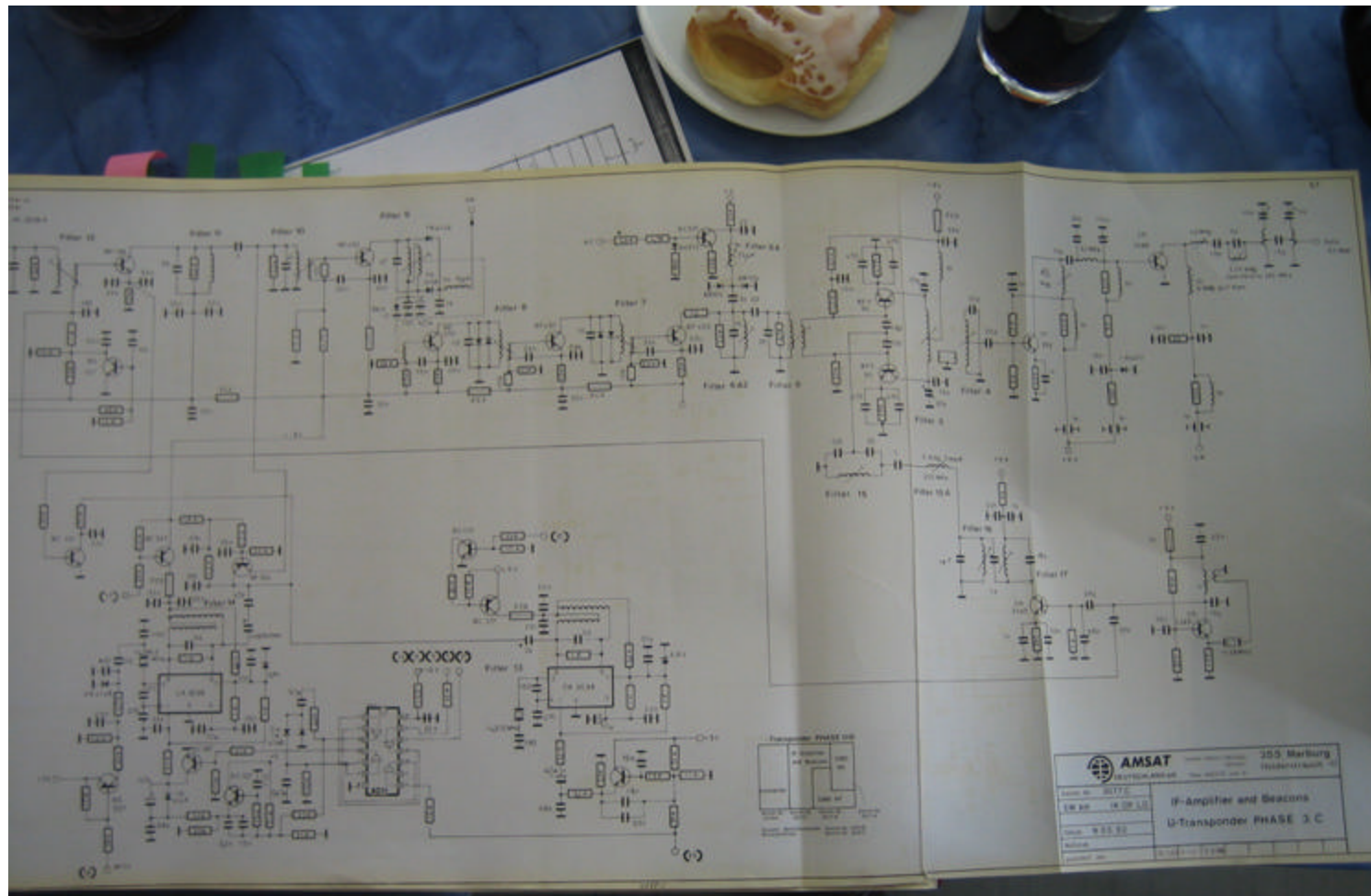


# Traditional Phase 3 linear transponders

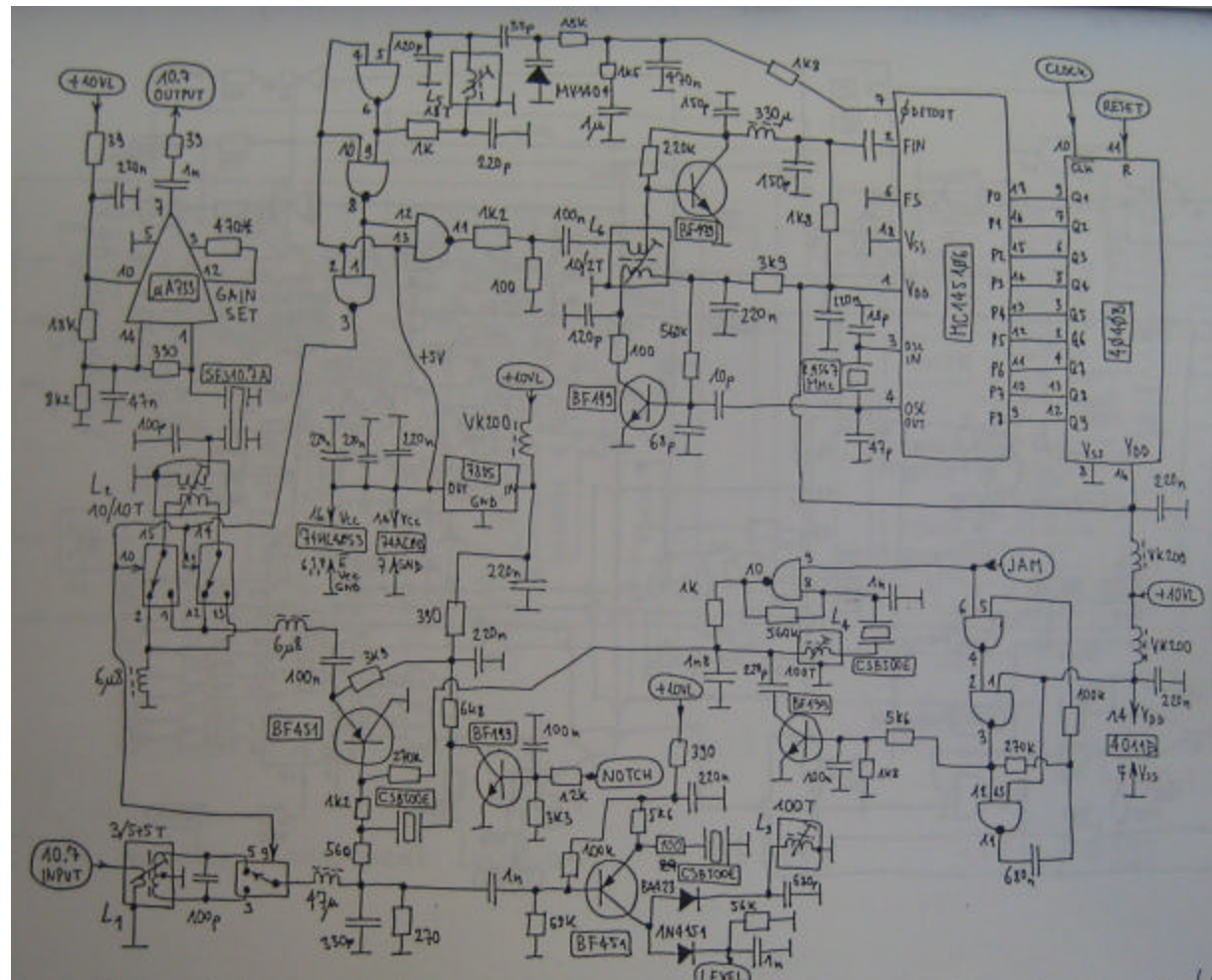


The schematic diagram illustrates a 100-MHz superheterodyne receiver. The signal path begins with an antenna connected to an RF amplifier stage (Mixer, 8F 100, 100 dB). This is followed by a 1st IF amplifier stage (Mixer, 8F 100, 100 dB). The signal then passes through a 2nd IF amplifier stage (Mixer, 8F 100, 100 dB), a 3rd IF amplifier stage (Mixer, 8F 100, 100 dB), and finally a 4th IF amplifier stage (Mixer, 8F 100, 100 dB). The receiver also features a 100-MHz oscillator and a 100-MHz reference oscillator. The output stage includes a 100-MHz discriminator and a 100-MHz limiter. The diagram is divided into two main sections: 'RF SECTION' and 'IF SECTION'. The RF SECTION includes the antenna, RF amplifier, and 1st IF amplifier. The IF SECTION includes the 2nd, 3rd, and 4th IF amplifiers, the 100-MHz oscillator, and the 100-MHz reference oscillator. The diagram also shows the power supply and the output stage. A photograph of the physical circuit board is included at the bottom left.

IF



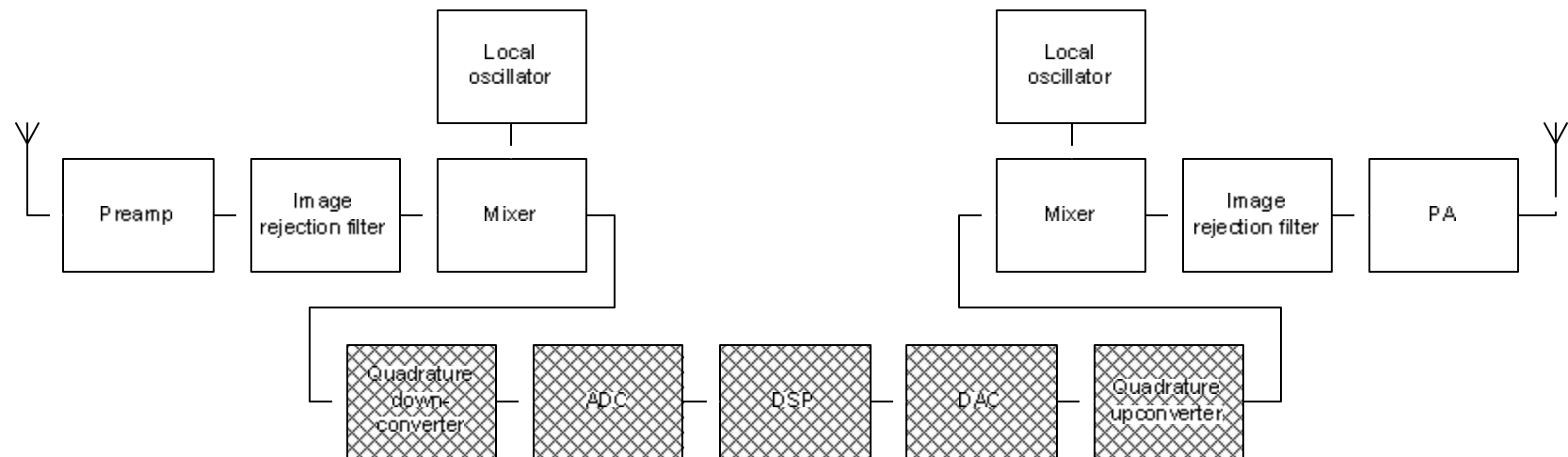
# LEILA - analog



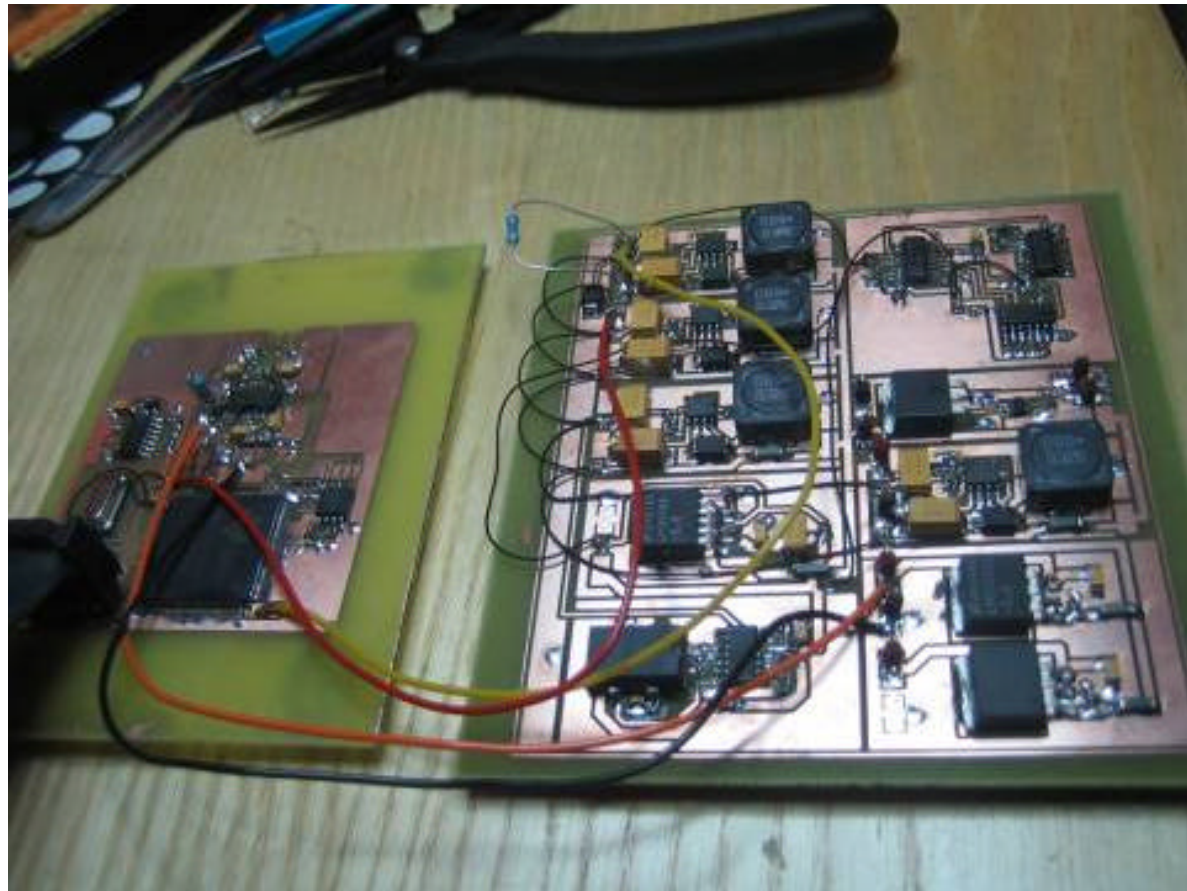


[illegible]

# SDX – the first step

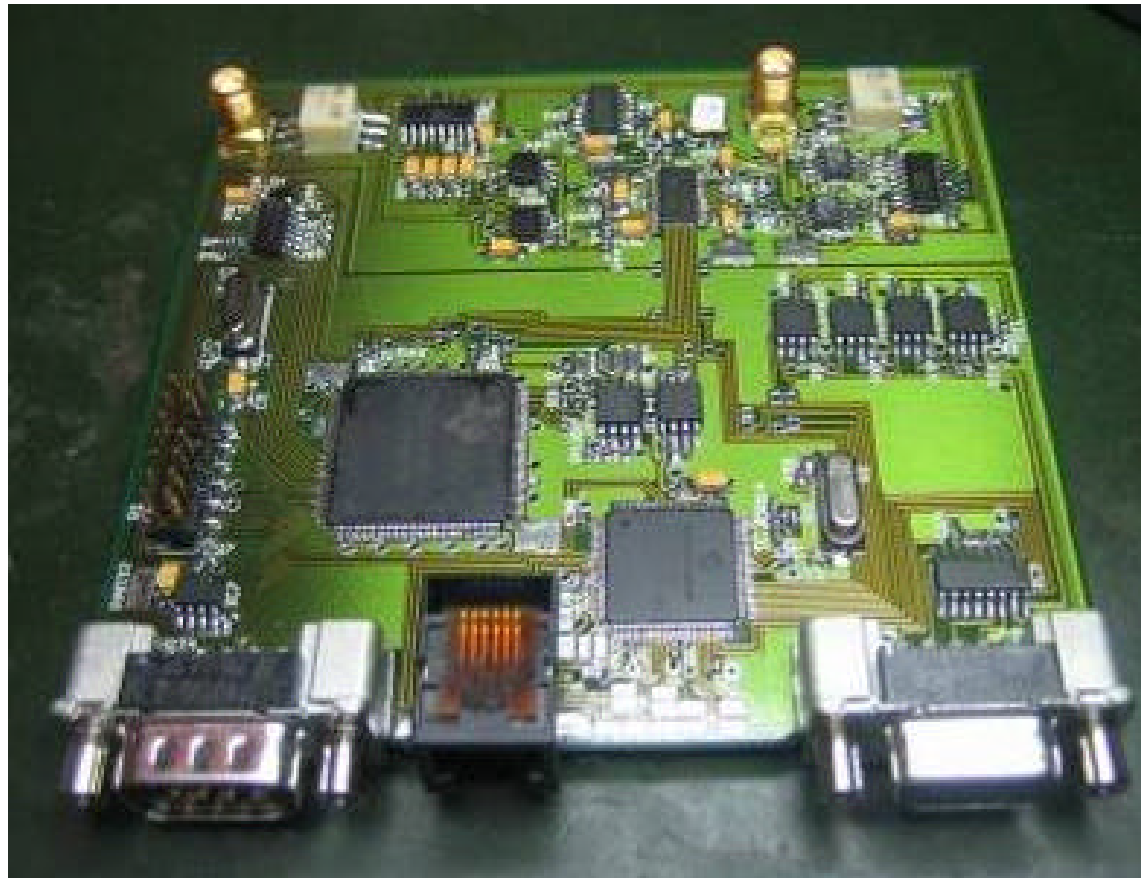


# SDX Mk 1

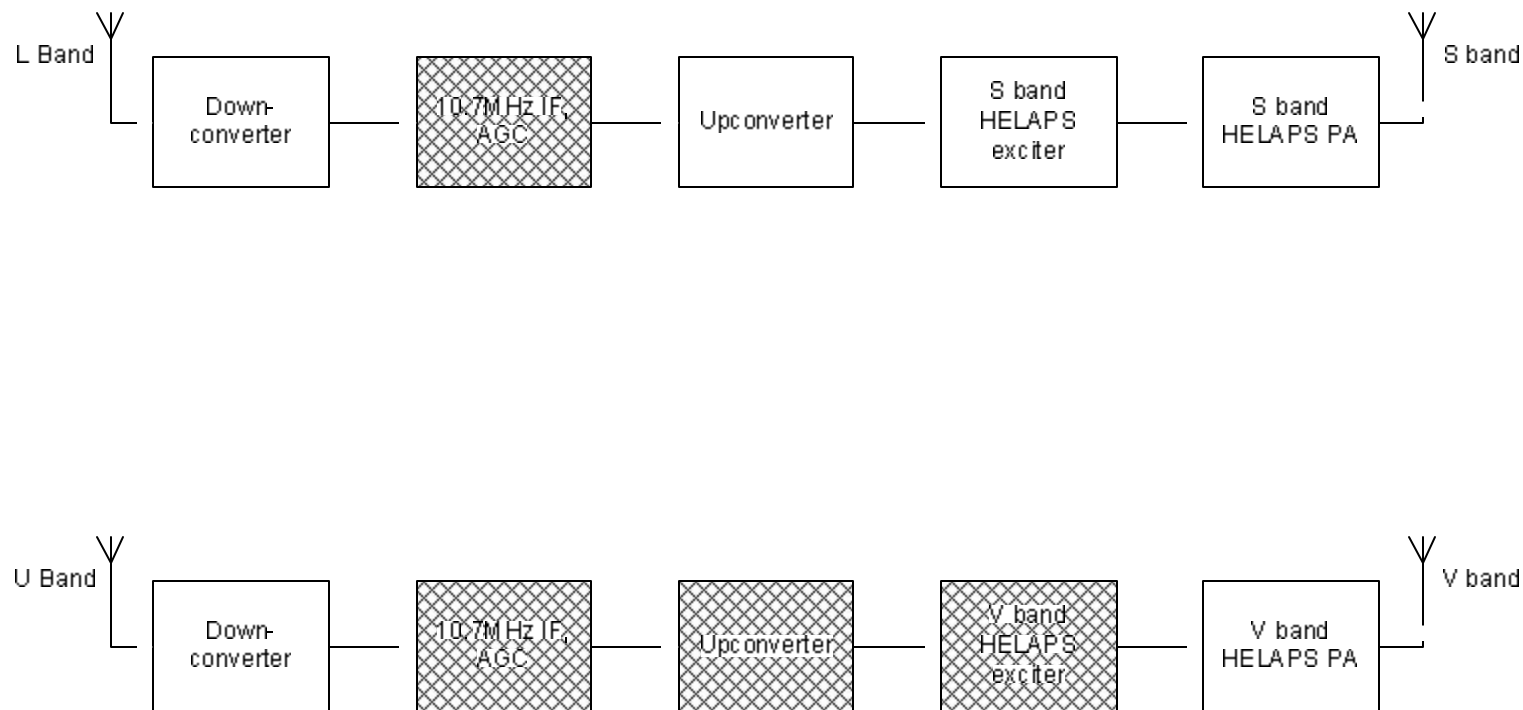




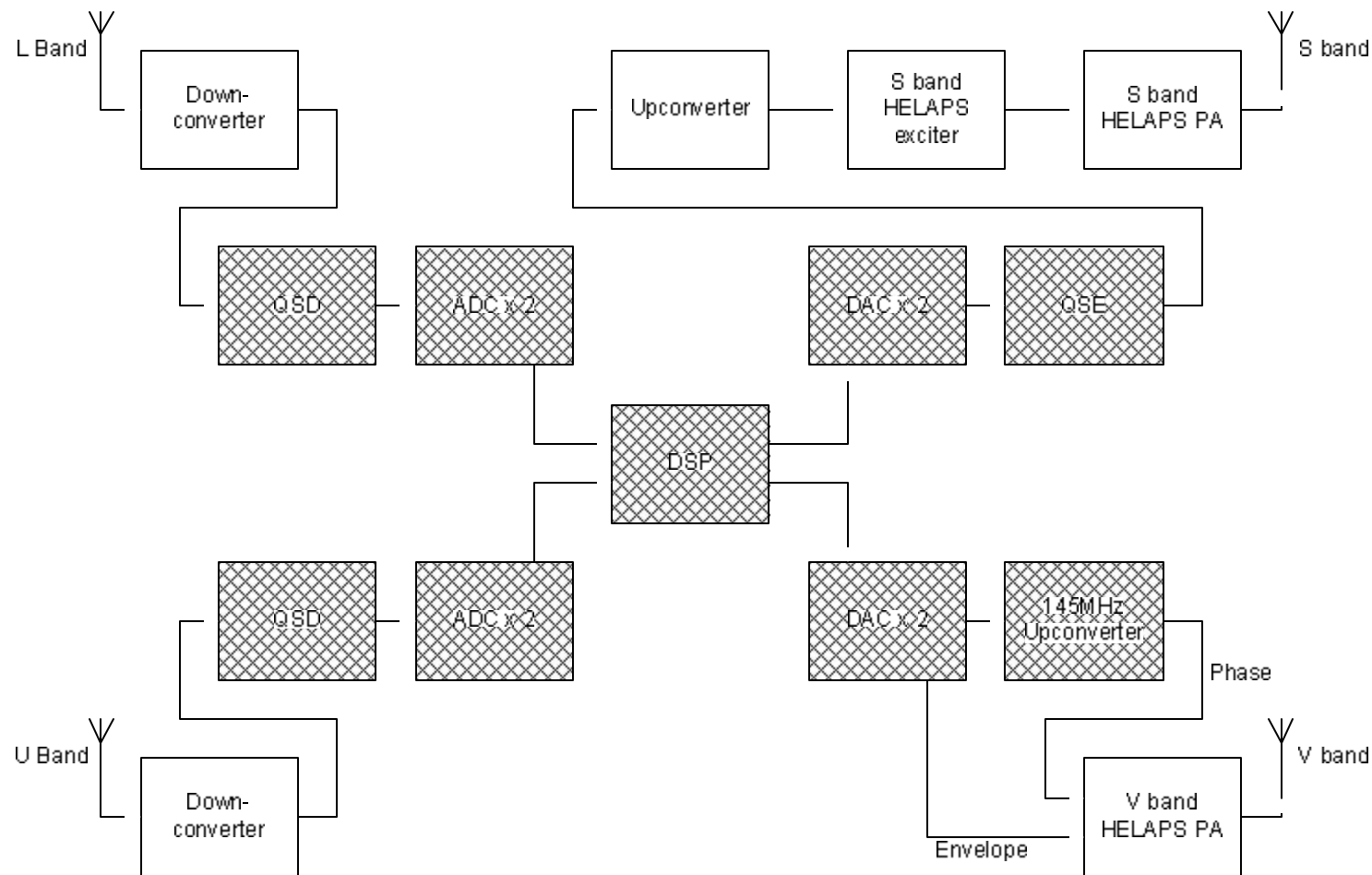
# SDX Mk 2



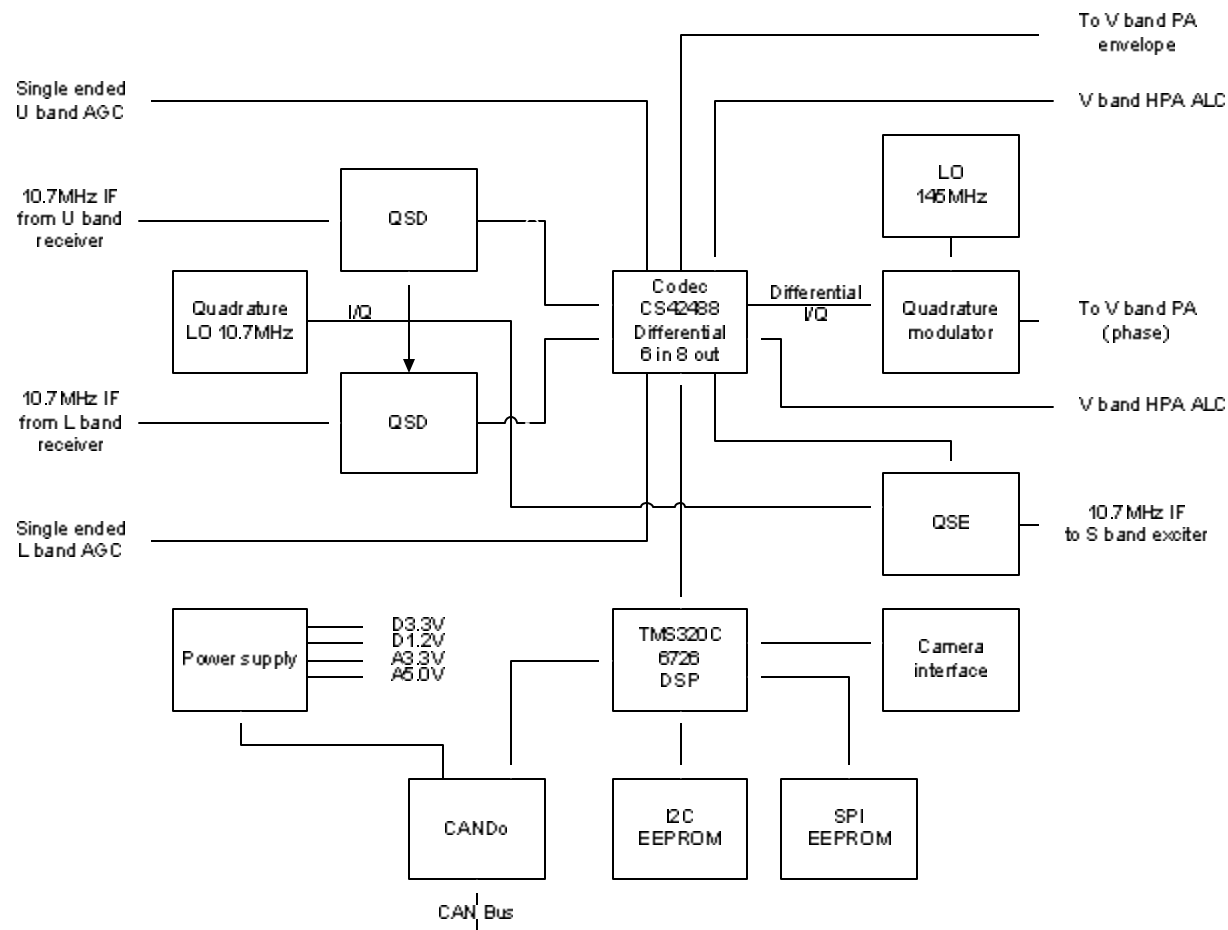
# P3E's original linear transponders



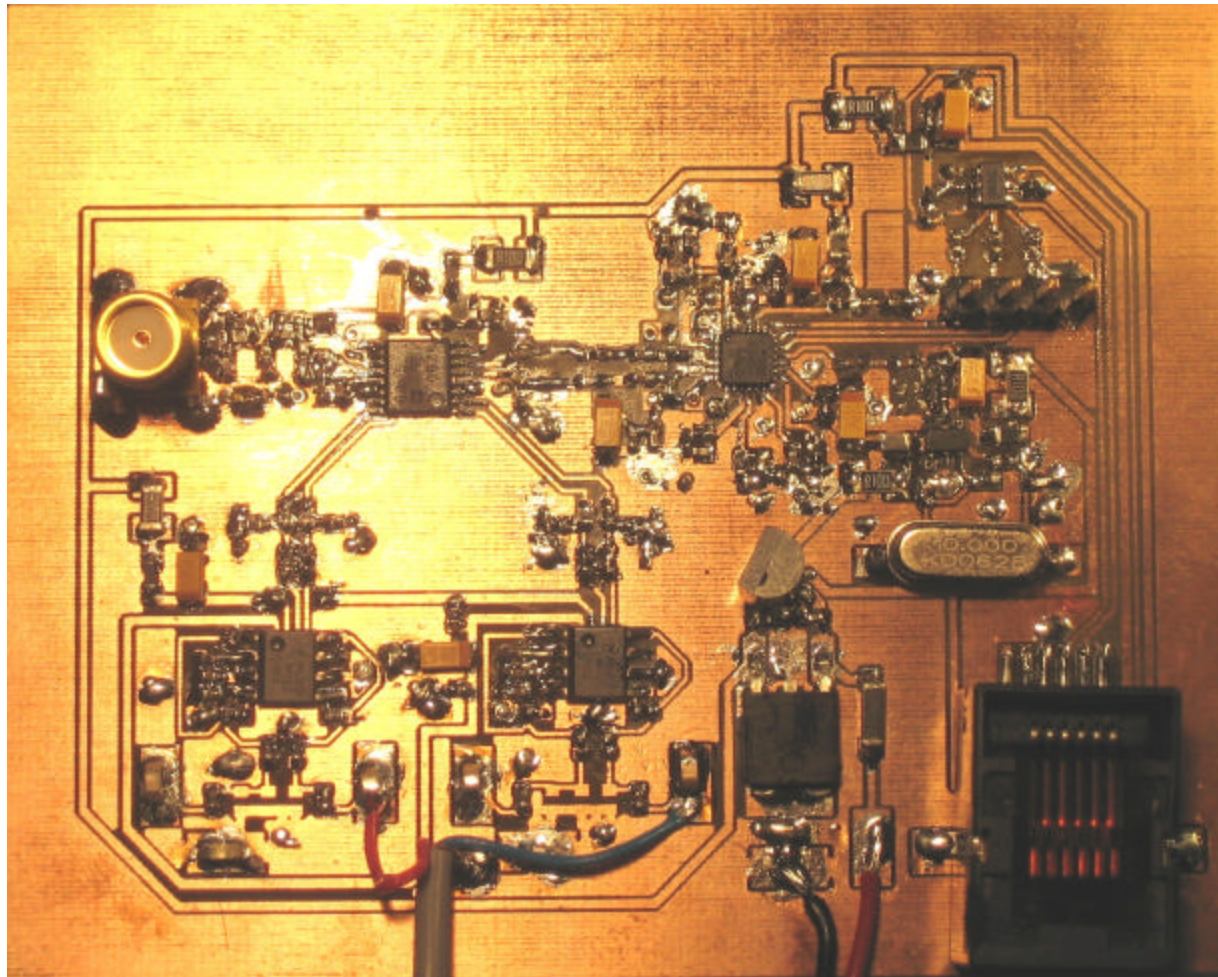
# P3E's new linear transponders



# P3E's SDX



# VHF exciter





# Designing for space

- ✍ Power
- ✍ Radiation
- ✍ Power
- ✍ Thermal
- ✍ Power
- ✍ Vacuum
- ✍ And...

# Power: think budget!

- ✍ Target is 1W for the SDX
- ✍ Use low noise, low power, differential techniques
- ✍ Use switch mode power supplies (SMPS)
- ✍ Use single low phase noise oscillator to derive all clocks (including SMPS!)
- ✍ Use low power technologies: eg, quadrature DDS and direct digital up/downconversion are power hungry

# Radiation

- ✍ We are passing through the proton belt
- ✍ It's not "if" but "when" an SEE occurs
- ✍ Accumulated total dose
- ✍ Electrolytics – leakage worsens over time
- ✍ Diverse memory
- ✍ Transition controlled watchdogs – autonomous KISS designs
- ✍ Dual processors: power cycle on crash detection
- ✍ Tantalum/aluminum shielding
- ✍ And...

# Power: think radiation!

- ✎ Over current protection
- ✎ Isolation of non essential elements (eg, camera)
- ✎ Immediate full power down of the entire system

# Thermal

- ✍ Sorry, fans don't work!
- ✍ Derate parts
- ✍ Careful PCB design to conduct heat away
- ✍ Careful construction and physical design (differing coefficients of expansion)
- ✍ C0G/NP0 (high precision analog)X7R capacitors
- ✍ And...

# Power – think thermal!

- ✍ Use SMPSs where possible – but consider noise implications in radio applications



# Vacuum

- ✍ Choose parts that have minimal outgassing
- ✍ Tantalum capacitors for decoupling, but derate: the failure mode is catastrophic!
- ✍ Ceramic capacitors for everything else, but consider the dielectric properties
  - ⌘ C0G/NP0 for precision analog
  - ⌘ X7R for long term timing (eg watchdogs)

# Designing for space – And...

- ✍ Tin whiskers
- ✍ Calibration
- ✍ COTS
  - ☞ Wide variety of devices
  - ☞ Cheap
  - ☞ Large production runs, thus reliable, and most failure modes have already been characterised and corrected
- ✍ But
  - ☞ Bulk CMOS is not good in a radiation hostile environment!

# Conclusion

- ✍ All the subsystems of the design have been unit tested
- ✍ Schematics completed
- ✍ Initial peer review conducted, and corrections made
- ✍ We need you!
  - ☞ Your peer review
  - ☞ Any good at PCB layout?

# Thank you!

✍ Questions?

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